The Oman Flora and Fauna Survey, 1975

David L. Harrison

THE STORY of this expedition has its origin in the concern which has developed in recent years for the future of the Arabian Tahr (*Hemitragus jayakari*). This unique species of wild goat, confined to the mountain ranges of Oman, seemed to be threatened with extinction. During the spring of 1973 we formulated a plan for a National Park in the Jebel Akhdar Range. The area we selected is centred on the principal peak of Jebel Akhdar, and is almost rectangular, about 50 km across and 30 km from north to south, in the Hajar al-Gharbi, just south of Rostaq.

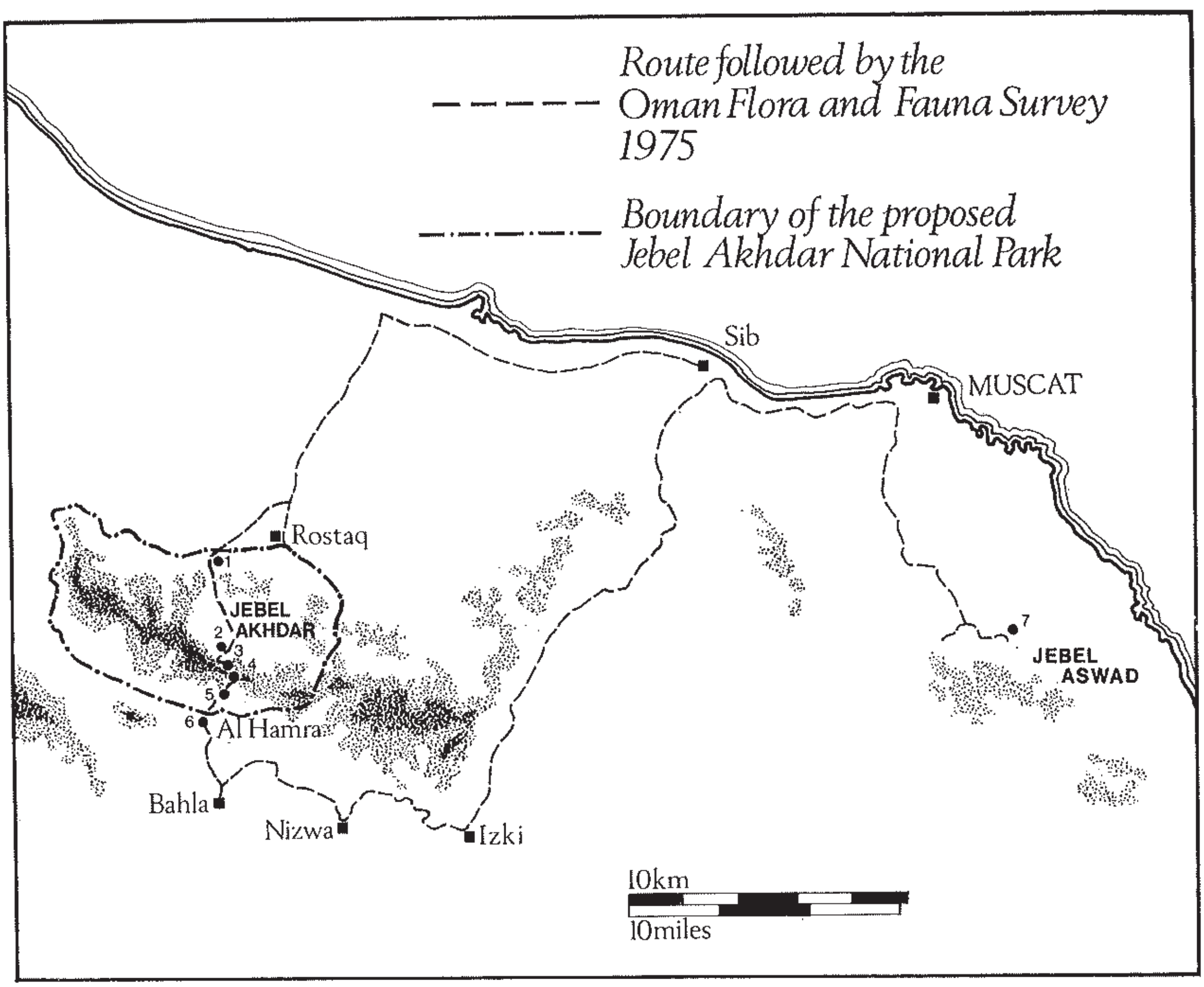

FIG. 1. *Map of the Muscat Region.*

PLATE 1. *A young visitor to our camp in Wadi Sahtan.*

PLATE 2. *Expedition member James Mandaville talks with local tribesmen at Camp 2 an-Nid.*

H.M. the Sultan of Oman expressed great interest in the development of such a park and a preliminary reconnaissance of the area was made by Michael Gallagher with a party of nine soldiers during a week in March 1973. Michael Gallagher's preliminary report was most favourable and suggested the need for a detailed scientific survey of the area selected.

During the month of April 1975 the author led a party of five naturalists to Oman to conduct this Survey at the invitation of the Oman Government and with their financial support. Our expedition also received enthusiastic support from the Fauna Preservation Society in London.

Our team consisted of the following members, with special interests as listed below:–

Dr. David Harrison	: mammalogy.
Major M. D. Gallagher	: ornithology, herpetology, ichthyology, conchology.
James P. Mandaville Jr.	: botany.
P. Granville White	: entomology.
Guy C. D. Harrison	: photography.

With only one month in the field and with all these varied interests to cater for, it was decided that the major part of our time should be devoted to an altitudinal survey of the flora and fauna of the Jebel Akhdar Range. This was carried out from north to south, using the route reconnoitred by Major Gallagher in 1973, crossing the main range between Rostaq and al-Hamra, ascending the mountains by Wadi Sahtan and descending by Wadi Misfah. This operation, crossing the whole area of the proposed National Park from north to south occupied nineteen days and involved the establishment of six different camps at varying altitudes as listed below. At each of these we stayed several days to collect samples of the flora and fauna for scientific study.

Camp 1. Wadi Sahtan, between Tabaqah and al-Khadra, 1500 ft.
Camp 2. An-Nid, Wadi Sahtan. 2500 ft.
Camp 3. Masjid Ma'illah, Jebel Akhdar. 6100 ft.
Camp 4. Birkat Sharaf al-Wadi Sahtan, Jebel Akhdar. 7000 ft.
Camp 5. Waterhole, near Bilad Aqabat al-Hamra, Jebel Akhdar, 4575 ft.
Camp 6. Al-Hamra. 1965 ft.

The locations of these camps and our route across the area of the proposed National Park are shown on the map (*Fig. 1*). The principal part of the trek, between an-Nid and al-Hamra consisted of mountain tracks, which could only be negotiated on foot. Our essential supplies and equipment then had to be transferred from our three Land Rovers and one four-ton truck on to the backs of thirteen donkeys. These were attended by a party of thirteen Abriyin tribesmen, drawn from the hill villages of an-Nid, al-Ghawr and al-Mibu, who acted as our guides on the mountain. The anxieties of this rather complicated operation were much relieved by a helicopter of S.O.A.F. which landed at Birkat Sharaf, our highest camp on the Pass at 7000 ft. to bring us essential supplies of food and other necessities. The opportunity was then taken to land some members of the party on the actual summit of Jebel Akhdar, almost ten thousand feet high, to carry out a rapid survey of the flora at this highest point of the range, and surveys were also carried out on foot up to 9000 ft from the higher camps, A full aerial reconnaissance of the whole area of the National Park had already been made from Camp 1. A Pilatus Porter monoplane of the Royal Oman Police was provided for this morning's survey, during which we were able to see and photograph the whole area in perfect weather conditions, an invaluable prelude to the trek over the mountains.

PLATE 3. *Jebel Akhdar scenery.*

Our splendid donkey transport, with their Abriyin owners, who proved so reliable and cheerful on our very exacting trek, were recruited for us by Major Michael Baddeley. At Al Hamra we rejoined our motor transport and proceeded via Bahla, Nizwa and the Sumail Gap back to the coast and on to our final Camp 7 in Wadi Qid, Wadi Sarin area, Al Hajar al-Sharqi. Here we spent six days with Major David Insall looking at the escarpment of Jebel Aswad, where he has established a reserve for the Arabian Tahr with Government help. Here we continued our survey of the flora and fauna of the range and again with the help of the helicopter visited the summit of Jebel Aswad, where several members of the party spent two days. Although our hope of photographing Tahr in the wild was unfortunately not attainable owing to the inaccessibility of the animals' haunts, this stay in Wadi Sarin added enormously to the variety and value of our botanical and zoological surveys.

We returned to Muscat on 25th April, our last days in the country being fully occupied with packing up our precious specimens for transportation back to England, as well as meeting Government Ministers and others interested in our work and a little relaxation after twenty-five strenuous days in the field. Time was however, found to make brief visits to the Nature Reserve recently established at Khor Qurm, close to the seashore, where much of ornithological and botanical interest was found, in and around the mangrove swamps.

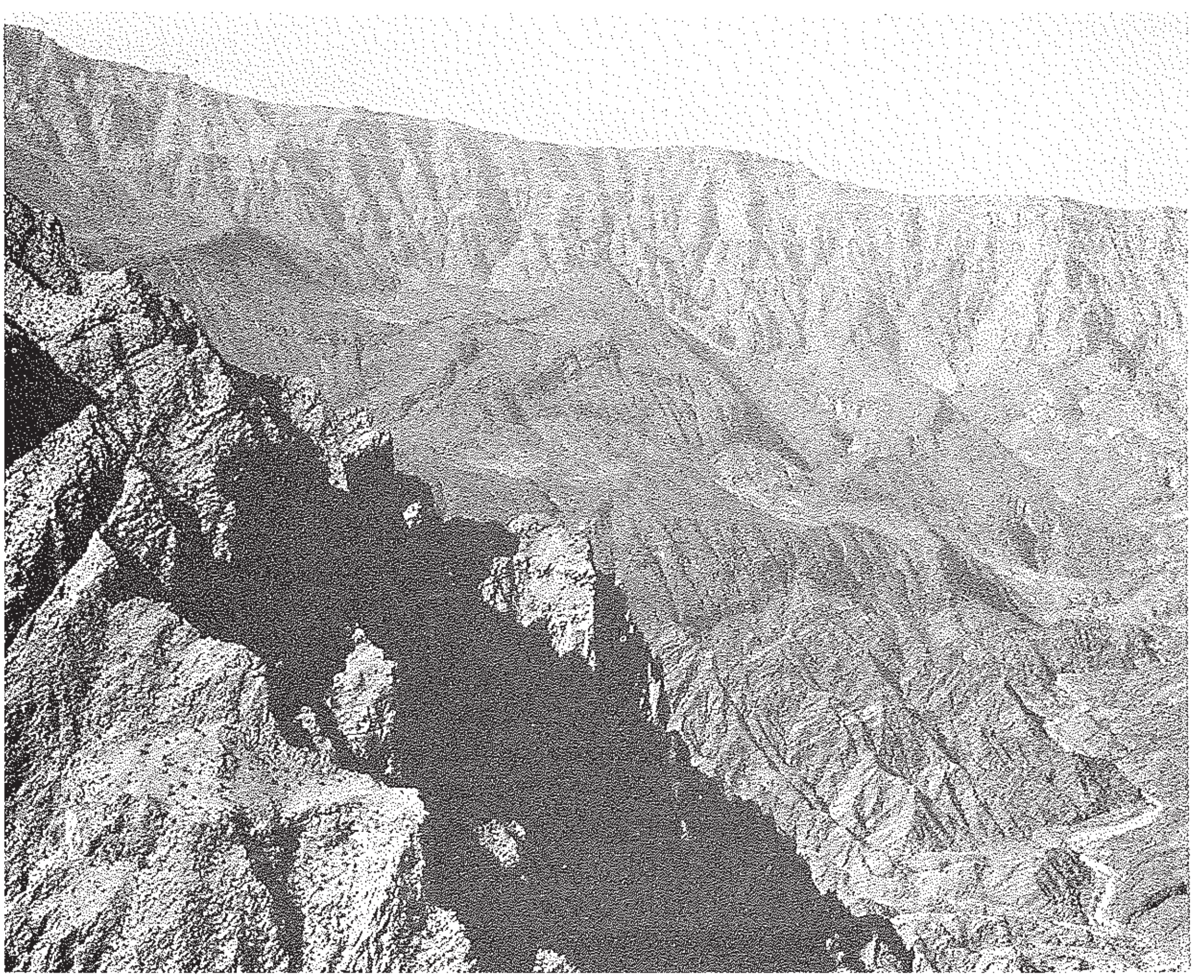

PLATE 4. *View from Masjid Ma'illah Jebel Akhdar.*

What results may be expected from our work? On the scientific side a large body of botanical (685 plant specimens) and zoological material (including 59 mammals, 43 birds, a smaller number of reptiles and amphibians and fish and a large selection of invertebrates) is now undergoing painstaking and detailed analysis. Scientific reports will be prepared and published describing this in detail.

We were all greatly impressed by the awe-inspiring grandeur of the rugged scenery of the Jebel Akhdar and amazed by the variety and beauty of its natural history. We are more than ever convinced that this area must be preserved as a National Park. The further information we have gleaned about the Tahr confirms its increasing scarcity; its shyness and the inaccessibility of its favourite retreats renders it a most difficult creature to study. During our visit a young male Tahr was brought in by tribesmen from a remote part of Jebel Aswad near Qatenayt. Our hopes of starting a captive herd were once again dashed when this youngster died of a fulminating septicaemia in spite of every possible care. The delicacy of young Tahr in captivity is thus far proving an insuperable difficulty in the establishment of a captive herd. The creation of a properly managed reserve for this species in the remote mountains of Sharqiyah is hence a most heartening development. It is much to be hoped that the population of Tahr will eventually recover in the Jebel Akhdar also, when this area is eventually established as a Park.

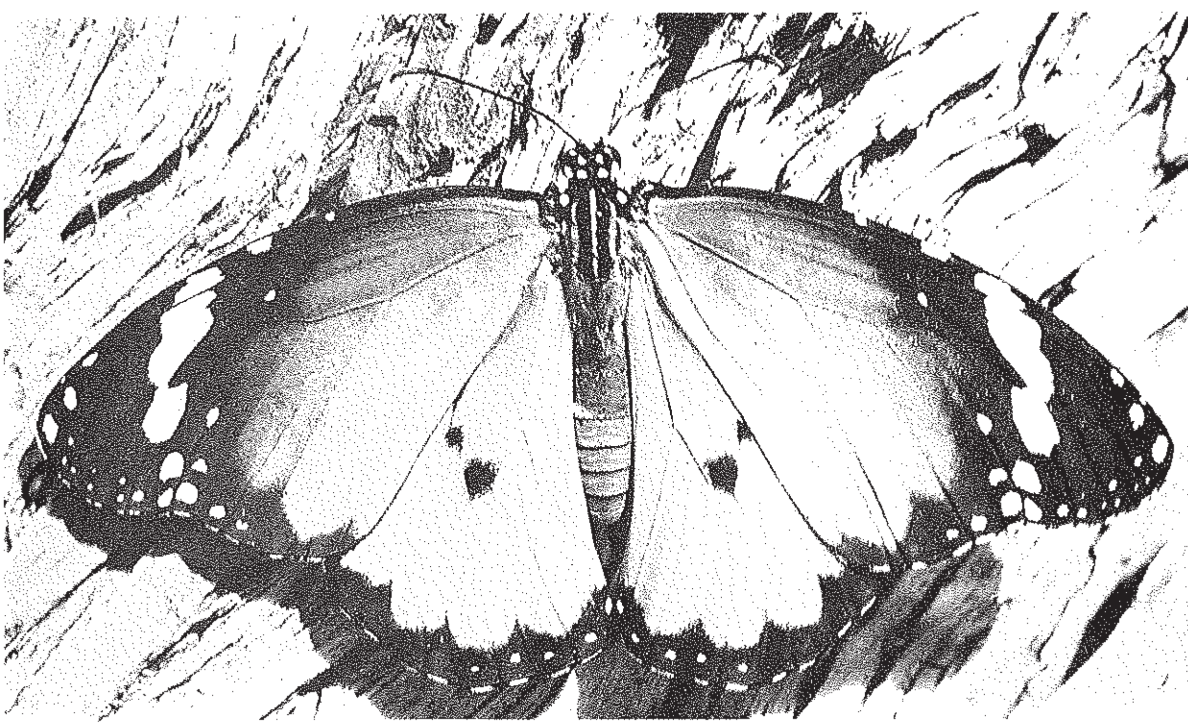

PLATE 5. Danaus chrysippus—*a common butterfly of the Jebel.*

In addition to the detailed scientific reports intended for specialists, we hope to produce an illustrated book of general interest. In English and Arabic editions, this will describe the main features of the area and the principal botanical and zoological finds we have made there. In this way it is hoped to promote general interest in the area and also a realisation of the unique and precious heritage of Arabian life that would be preserved for future generations to enjoy and study in the Jebel Akhdar National Park.

Photographs by G. C. D. Harrison.

Notes on the Distribution and Exploitation of Natural Resources in Ancient Oman

Maurizio Tosi

Introduction

NORTHERN OMAN is situated between 22° and 24° 30′ latitude North on the Tropic of Cancer. It is included in the sub-tropical zone with arid climate. The low rainfall varies throughout the year from 171 mm at Nizwa to 36.1 mm at Sohar. Although insignificant for dry farming depending on larger atmospheric precipitation these brief rains are nevertheless sufficient to supply a widespread system of water-bearing layers in the foothill area. Abundant water supplies are thus one of the geographic features typical of the coastal and predesertic piedmont strips of Oman so that, in spite of its dry climate, the region favours a much richer and more diversified biotopic development than that found in nearby Baluchistan. Human settlement has thus been possible there from prehistoric times. The availability of water was instrumental in the exploitation of a wide range of economic resources. In the palaeo-economic survey that we outline in this preliminary communication, water is thus a constant reference point in the determination of the settlement model and the degree of demographic concentration, while the primary variables, which are decisive for the purpose of reconstructing the production mode and the typology of the cultural complex, are made up of the other resources, whether they be agricultural, marine game or mineral.

In a survey of the patterns of production and exchange incidence, the researcher working in Oman is highly favoured by the same geographic distribution of the resources which appears as a series of parallel strips running roughly along the NW—SE axis of the north coast from the Musandam peninsula to Ras al-Hadd. The importance of correctly interpreting archaeological research in Oman from the palaeo-economic standpoint is underlined in particular by the distribution of the so-called Umm an-Nar culture and by the 'Jemdet Nasr' horizon which seems to precede it (Frifelt, 1970; 1975b). Although the models of its pottery assemblage are very close to those of Iranian Baluchistan, the Umm an-Nar cultural complex displays an extraordinary homogeneity over a period of perhaps more than 500 years (2600-2000 B.C.) and is scattered in small settlements over a very wide area south of the Oman mountains, between Abu Dhabi to the NWW and the Sharqiya plain to the SEE (Thorvildsen, 1962, Humphries, 1974). This is a distance of about 450 km, in a region in which the environmental conditions and the economic resources vary very widely. The corresponding cultures in south-eastern Iran, which can probably be recognised in the cultural assemblages of the Yahya IVB and Bampur III-VI (Lamberg-Karlovsky, Tosi, 1973:44) horizons, in spite of their high technological level and their better connection with a complex long-distance exchange network, are found to be much more limited as regards territorial expansion and diachronically highly variable.

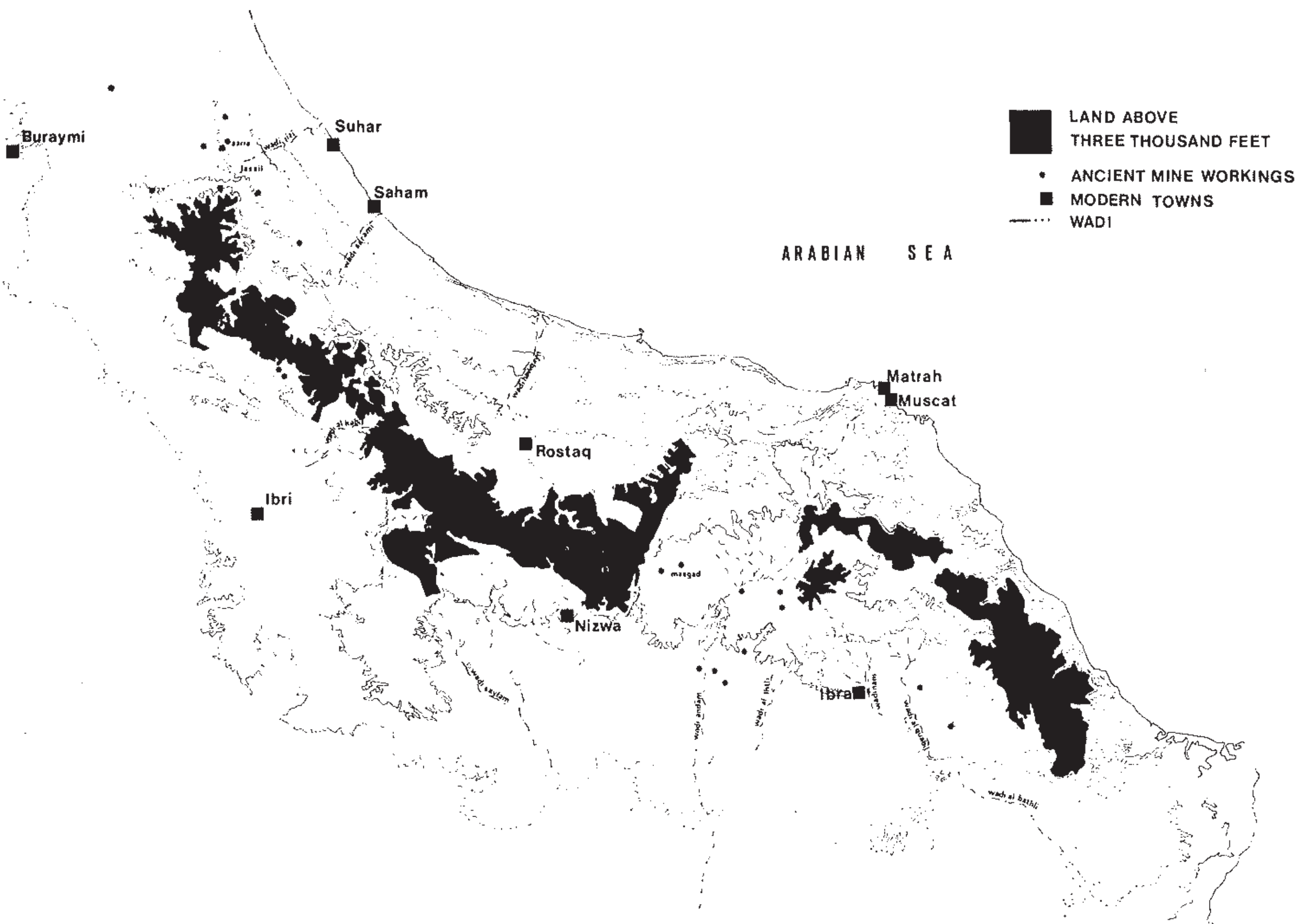

FIG. 1. *Foothill strips and distribution of ancient copper mines in northern Oman (drawing by B. Polia from data kindly provided by Prospection Ltd.).*

Over the last four years the work of Karen Frifelt and of the Harvard University Archaeological Mission has provided a good documentation of the geographic distribution and the historical importance of the Umm an-Nar culture in Oman. The latter consists of a complex of socio-economic experiences of such a size and extending over such a long period of time that it could perhaps be considered as a platform on which to a good extent the development of the entire history of the Arabian peninsula is based. We thus thought it was worthwhile making a contribution to the important research being carried out in Oman by means of a series of specific investigations into the economic determinants in order to help the work of the other Missions and to provide the Department of Antiquities with a useful instrument for planning its future activity.

In view of the fact that the Italian Institute of Human Palaeontology in Rome had both specialists and investigation equipment available in the field of the natural sciences and had also been carrying on activities related to interdisciplinary research for more than fifty years, Andrew Williamson thought it would be a good idea to invite us to carry out a preliminary reconnaissance in Oman for the purpose of assessing the objective chances of a scientific cooperation undertaking between the Institute itself and the various Missions operating in the country. It is worth stressing at this point the far-sighted views of the late Adviser on Antiquities who, from the beginning, had striven to provide Oman with specialist

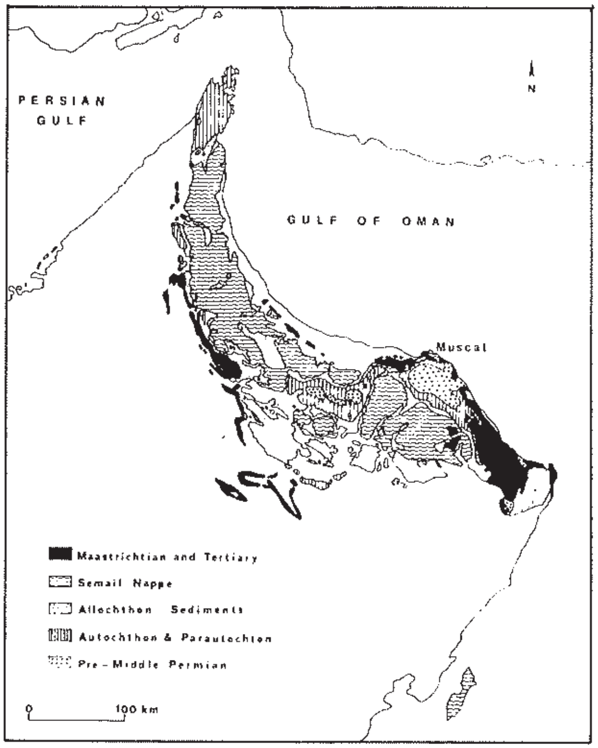

FIG 2. *Geological scheme of Oman Mts. Sumail Nappe can be identified by the ophiolitic belt rich in copper-bearing mineralizations (from Koninklijke Shell, 1969).*

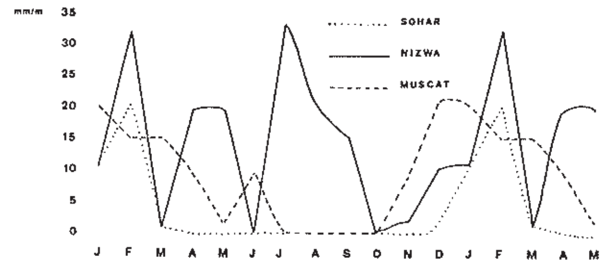

FIG. 3. *Average rainfall in three typical Oman localities, with two annual peaks and intermediate dryness. Note the rainfall distribution at Nizwa in the inland foothill strip.*

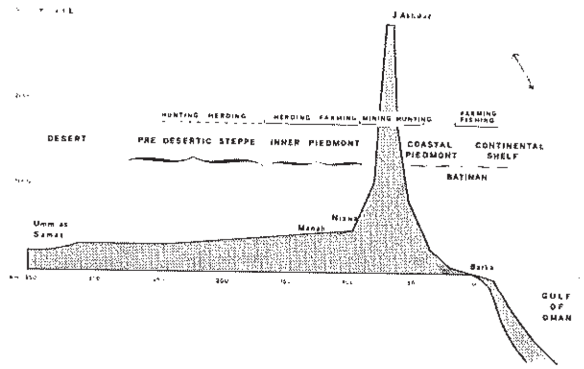

FIG. 4. *Profile of altitudes above sea level according to the Barka-Umm as-Samat section. The main resources available to a proto-historic, tendentially autochthonous economy are marked (drawn by I. Reindell from a sketch by A. Segre).*

teams that were highly advanced technically and available for a research plan in keeping with the country's projects of social and economic development.

Acknowledgements

Our visit to Oman took place between March 25 and April 5 1975 by invitation of the Ministry of Information and Culture. Participating with the author was Dr. Marcello Piperno. Travelling costs were covered by the General Direction for Scientific and Cultural Cooperation of the Italian Ministry of Foreign Affairs.

The extensive, generous aid we received from local or foreign organisations and individuals operating in the country allowed us to get the most out of our short stay. We should thus like to express our thanks especially to the Department of Antiquities. Our warm thanks also go to the Historical Association of Oman which, through Leslie Pickard, was of considerable assistance to us during our journey to Wadi Jizzi. We are also very grateful to R. Jäckli and J. Jennings who always stood by us with their large contribution of equipment, data and materials, enabled us to make a correct approach to the scientific and logistic problems involved; to N. Firth and the geologists of Prospection Ltd., who, in addition to data in their possession, generously put at our disposal a helicopter, motor vehicles and personnel to facilitate our visit to the ancient mines of Wadi Jizzi and Luzaq; to J. Humphries and the members of the Harvard Archaeological mission who kindly gave us hospitality and informed us of all the results obtained during their reconnaissance work. Lastly, we have great pleasure in extending to Ing F. Passariello of Sogex our gratitude for the great kindness he showed us.

Geomorphology. Territorial subdivisions

Few regions in the world have been so conditioned by continental shelf tectonics as northern Oman. A cross section running NNE—SSW taken ideally from Birka on the coast as far as the Umm as-Sammim depression (315-330 km as the crow flies), clearly shows the coastal wrinkling of Jebel Akhdar. (*Plate 4*). In the short space of sixty or so kilometres there is a difference in level from 0 to about 3000 metres a.s.l. At a distance of about 95 km from the coast, near the rich oases of Bahla and Nizwa, we dropped 500 m and then descended a regular slope as far as the edge of the Umm as-Sammim, 200 km away in the Rub al-Khali. Because of the dramatic variations in altitude that it determines over 100 km or so of cross section, the Jebel Akhdar forms a real wall between the coast and the interior, which brings about a distribution of the economic resources in a direction parallel to its ridge line. From the flat surface of the mountain to the centre of the desert depression or the sea, the environments vary both vertically, as a function of height above sea level, and horizontally, as a function of distance from the *wadi* (*Plate 1*). This consequently gives rise to natural variations in countryside and availability of resources even in areas that are very close together. The sub-tropical coastal climate along the coast and in the Sharqiya is conducive to open *Acacia* savannah (*Plate 2*), makes the population of plant species much thicker and more varied than in nearby Baluchistan. The flora-fauna diversification in the territory is brought about by a number of factors such as variations in altitude, the divergent action of two climatic constants (the desert, to the interior and the Indian Ocean), the different rainfall characteristics determined by the orographic "wall", and by the short distance from the Indian monsoon. However, the dry climate tends to increase these biotopic differentiations. After adapting to these conditions, flora and fauna are arranged into concentrations that are sharply delimited and fairly highly specialized according to a definite range of resources. The human community which then must depend on them is compelled to follow a similar logic and has to diversify the type of settlement structure. The architecture of the buildings, production mode and technological specialisation vary according to principles similar to those adopted by the flora and fauna. J. C. Wilkinson has in fact shown how each of the three physiographic provinces—desert, mountain and coast—stimulated a peculiar specialisation in land use without however bringing about any subdivision, segregation or a specialisation of a socio-economic nature, thanks to the development of mechanisms of interaction favoured by the short distances and the complementary nature of the resources (Wilkinson, 1974: 5-7).

The Oman mountains are mainly formed by allogenous thrust sheets deposited on an autochthonous, pre-Cambrian sequence of metamorphic basement (Carney & Welland, 1973: 26-28). We are thus dealing with a thrust zone where, in association with tectonic contact alignment, we also find an ophiolitic belt, probably deriving from early Cretaceous vulcanism, that is characterised by serpentinites, peridotities, gabbro and by an intrusive doleritic complex. (Carney, Welland, 1973: fig. 2.1). These are the rocks which provided ancient Oman with one of its greatest riches—copper. The ophiolitic belt thus gives rise to a further zone in the economic geography of Oman whose importance, judging by the number of ancient mines discovered (*Fig. 1*) can be considered as being very great in the country's history.

On the basis of the above considerations and of the present conditions of the country, let us now define the environmental areas into which, in our opinion, the territory connected with the Umm an-Nar culture ought to be subdivided for the purposes of future investigation.

1. *The coast.* This is made up of beaches, reefs, small coastal islands and the immediate inland area, with the estuaries of the *wadis*. Marine resources prevail here, although on the Oman coast between Khor

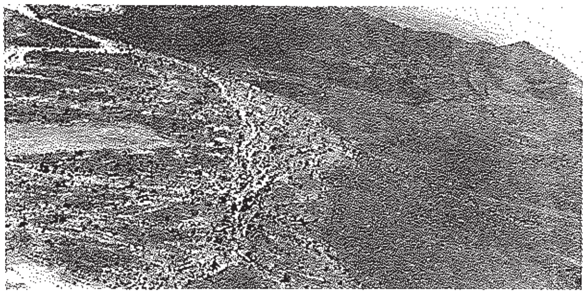

PLATE 1. *Nizwa area: distribution of vegetation in close correlation with course of foothill* wadi.

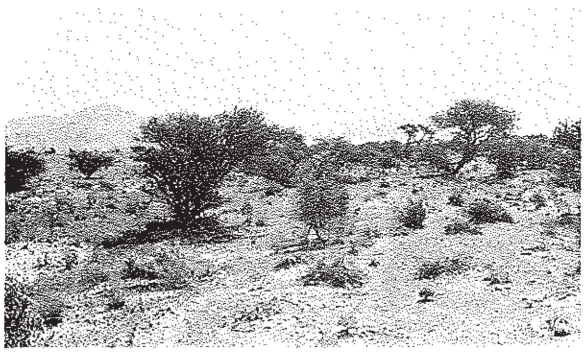

PLATE 2. *Wadi Aday: open* Acacia *savannah covering the entire between-mountain alluvium.*

PLATE 4. *Close-up of surface of Qurm 1. In the middle, a net weight made from a grooved stone. All around are remains of* Potamides palustris *with its characteristic grooved surface.*

PLATE 3. *The shell-mound of Qurm 1 seen from the NE. Note its position on a small creek with riparian mangrove forests. This is the environment of* Potamides palustris *L., which was widely consumed in the old settlement. On the left of the tell you can see the line of the nummulitic limestone bank on which part of the archaeological deposit rests.*

Fakkan and Ras al-Hamra, the coastal plain (Batina) has an average width of 20 km and is crossed by deep *wadis* and wide fluvial terraces that have favoured the development of intensive farming in the *Acacia* savannah area.

2. *The coastal foothill strip.* This runs from 100 to 750 m a.s.l. parallel with the Batina plain from Wadi Aswad to Wadi Sumail. The gravel detrital cones make human settlement difficult and unlikely outside the main *wadi* courses where the settlements occupy the side valleys and the older terraces. According to Carney and Welland (1974: 3-4) the regression of the marine terraces (from the post-Maastrichtian Tertiary) led to a rejuvenation of the river terraces upstream accompanied by a large variation both in the shore lines and in the watercourses. This supposedly had the result of increasing the instability of the settlements.

3. *The mountain chain.* This is inhabited by average mountain fauna which still survives in places (Harrison, 1968) and is studded with copper-bearing ore outcrops.

4. *The interior foothill strip.* Here rainfall reaches the peak levels of the whole of eastern Arabia (170-200 mm yr), underground water is plentiful and satisfactorily collected in the *wadi* basins in which all the vegetation is distributed. There are numerous oases. Although this strip is 80 km wide, the zone of optimal exploitation is situated on the mountain slopes on a 500 m a.s.l. contour line. It virtually takes in all the territory between Buraimi and Izki. In the larger *wadis*, the more intensive farm settlement area shifts upstream to about 650-700 m a.s.l. at the points where the *wadis* run into the foothill plain. This is what the situation is like in Wadi al-Kabir, Wadi Amlah, Wadi Sayfam, Wadi Halfain.

5. *The Sharqiya Plain.* Apparently similar to the above, although differing from it in its lesser exposure to the desert sand and in being relatively open towards the Indian Ocean to the east. The result is a vegetation richer in species and individuals. The settlements and arable land are linked to the catchment basins of Wadi Andam (about 900 km^2) at the smaller Wadi Samad and Wadi Ithli, and Wadi Batha (about 2200km^2).

In the rest of the country we find only clusters of mountain and coastal settlements while the desert prevails in the interior, the granite formations of Saih Hatat and the Oligo-Miocene limestones of Jebel Bani Jabir (Glennie et al., 1974).

This territorial subdivision is based on geographic criteria and is certainly not directly applicable to historical problems without being extensively compared with the archaeological data in our possession. The scantiness of the latter thus makes our work little more significant than a pure formulation of methodology. However, it must be pointed out that the very poor state of preservation of the archaeological deposits and the absence of cave or shelter sites will always make it difficult to carry out a localized study of the diachronic series. From many standpoints, the success of archaeological research in Oman will still be bound to the application of data concerning the surrounding regions mediated by an inductive formulation in anthropological and palaeo-economic schemes, combined with an analysis of environmental data which is as accurate as possible. It is our most fervent wish that future discoveries make the picture less gloomy, although still respecting the principle that the greater our awareness of our limitations and the clarity of the programmes the less likelihood there will be of precious data being destroyed.

Let us now attempt to gather together the small amount of palaeo-economic knowledge available in each of the five areas listed above.

PLATE 5. *Qurm 1: section of the W face of the unauthorized area. Note the stratification into shell layers of varying thickness. The two niches in the wall were left when samples for radio-carbon determinations, currently in progress, were removed.*

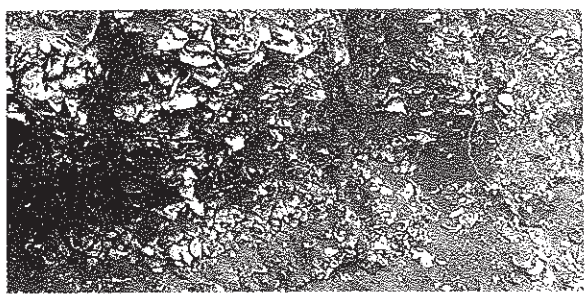

PLATE 6. *Qurm 1: close-up of east wall with obvious pebble layer in which is a lense of blackish ash.*

PLATE 8. *Ras al-Hamra: masonry made of blocks of coral limestone. In the foreground, concentrations of pebbles and broken shells.*

PLATE 7. *View of Ras al-Hamra from Qurm 1. The arrows mark the position of the settlements located on the reef.*

Marine resources

Throughout its length the coast of Oman represents a very favourable biotope for marine life. Contributing to this state of affairs are the steep slope of the continental shelf, the strong coastal currents, the water temperature (22°C in February, 26-32°C in August), the average degree of salinity (35‰). Molluscs, gasteropods, coelenterates and fish are extremely plentiful offshore, and create an environment that is very favourable to fishing and gathering.

Along the 140 miles from the sandy bay of Ghubbat al-Hail to the rocky hills of Khatmat Milaha runs the most important stretch of the Oman coastline from the economic viewpoint—the Batina, a strip only a few kilometres wide, barely 7–8 metres a.s.l., abounding in wells drawing upon the foothill water table, which also supplies a few small perennial creeks running into the sea. The availability of both farm and marine resources has made the Batina one of the cornerstones of human settlement in Oman. Prehistorically speaking, the data at hand is scanty but particularly promising. Of these the Ras al-Hamra promontory provides a series of aspects of great interest, and we are grateful to R. Jäckli and J. Jennings for drawing our attention to such a significant area, a group of sites on the western reef of the promontory facing Qurm beach (*Plate 7*). This was probably a fishing village, as seems to be indicated by the surface finds gathered by Jäckli and Jennings: weapons, chisels and knives of bronze (*Plates 9a & b*), broken shells, fish-bones, weights for fishing nets made of grooved stones. The settlements have the appearance of slight dome-shaped mounds, 15–20 metres in diameter, and are concentrated particularly on the westernmost edge of the cape, to the west of Sifat al-Ghar, one of the small beaches which breaks the continuity of the rocky coastline. It is conceivable that sites of this kind were to be found also on the remainder of the promontory, as seems to be indicated by a number of remains on the western tongue of Ras al-Abyad (*Fig. 1*) found by Jäckli. The dating of these villages is uncertain and they probably correspond to several occupation periods over quite a long period of time. The condition of the archaeological deposit and the absence of pottery make it rather unlikely that they belong to a very recent period. Certainly contemporary with the settlements are the numerous funerary cairns—more than 40—found by Jäckli lying in groups or isolated behind the settlements themselves. In accordance with a scheme of distribution typical of these graves throughout Oman they are mainly situated on rocky outcrops and ridges. They appear as low circular mounds built with blocks of limestone, varying in diameter from 2 to 6–7 metres.

The most important settlement in the area lies, however, not on the cape but on the Qurm beach before it (*Plate 3*). This is a true shell-mound (Qurm 1) which is similar to those found throughout the Pacific area. It is oval in plan (75.60 × 43 m) wholly composed of shells, fish-bones and the remains of a stone industry obviously specialised in fishing and the gathering of molluscs. The mound rises to a height of 3–4 m. The south end abuts a spur or marine terrace of sandstone while to the west it is virtually delimited by the Wadi Qurm, a brackish watercourse flanked by a small mangrove forest. This is an ideal position for a settlement of fisherman/gatherers owing to the ready availability of food resources from the sea (fish, molluscs), from the stream (molluscs) and from the interior (game). North of the mound a recent excavation has revealed the stratigraphic section which, over the entire depth of the deposit, is characterized by layers of broken shells often alternating or mixed with levels of pebbles, ash and charcoal fragments with an average thickness of 30 cm (*Plates 5–6*). Two samples were taken from this section, each weighing 0.5 kg, for the purposes of radiocarbon dating. In Rome they were also examined by S. Durante, malacologist of the Italian Institute of Human Palaeontology.

PLATE 9A. *Ras al-Hamra: surface finds. Fragments of bronze fish-hooks, chisel heads.*

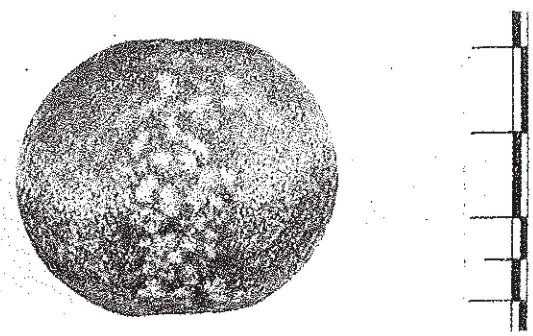

PLATE 9B. *A small pebble that had been chipped for use as a weight for a throwing net. Date uncertain.*

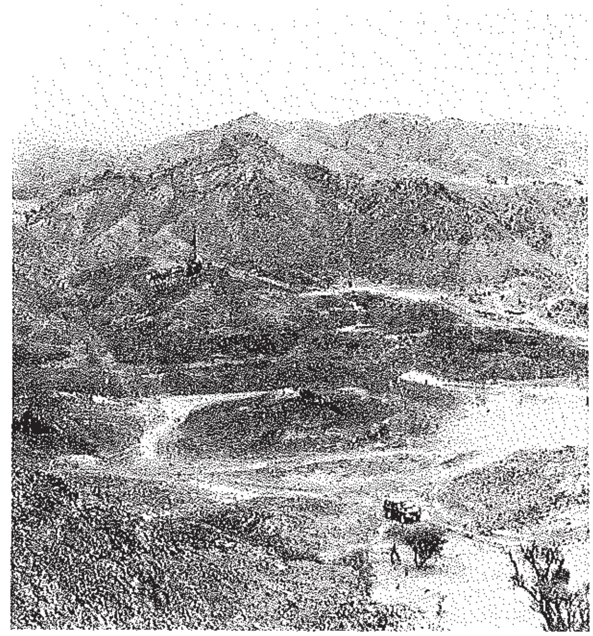

PLATE 10. *Lasail. Overall view of hollow between hills. The mounds of slag are interspersed with open spaces covered with powdered limonite.*

PLATE 11. *al-Lasail. Detail of a slag heap.*

Durante identifies the following species:

1. *Upper layer* (—25 cm from the edge of the section)
   —6 *Strombus* (*Conomurex*) *decorus persicus* Swainson;
   —5 *Potamides palustris* L. (= *Terebralia palustris* L.; = *Pyrazus palustris* Brug.; = *Terebralia sulcata* Born.)
   —12 *Arca* cf. *auriculata* Chem. Very broken.
   —20 *Ostrea sp.* Fragments.
   —*Pycnodonta* sp.

2. *Lower layer* (—60 cm from the edge of the section)
   —25 *Potamides palustris* L. Fragments.
   —15 *Arca* cf. *auricolata* Chem. Fragments.
   —30 *Ostrea* sp. Fragments.
   —1 *Pycnodonta* sp.

These are the remains of shell-fish gathered for food and eaten on the spot immediately. They are all shallow water varieties. What is characteristic is the presence of shallow-water marine forms, such as *Strombus decorus persicus*, a subspecies living in the Persian Gulf and along the coasts of the Gulf of Oman, and *Potamides palustris* (*Plate 4*), a species typical of the estuaries of tropical rivers where it lives in large colonies among the roots and branches of the mangrove forests. These are the conditions prevailing also today at Qurm 1. The settlement exploited the *Potamides* population, which was possibly the main food resource in the *wadi*, and it turned to the shallow water off the beach to satisfy its other needs.

The situation at Ras al-Hamra/Qurm is repeated in various places along the Oman coast, especially along the Batina, which is known to be characterized by this combination of land and sea resources—a mixed economy guaranteeing even and high subsistence levels based on available coastal resources.

It is important to stress the degree of adaptation and technical specialisation clearly revealed by the stone and metal implements and which is convergent with what has been found in the other economico-territorial subdivisions we have dealt with. The presence of bronze at Ras-al-Hamra and of shells in almost all the protohistoric settlements of the interior is an unusually immediate attestation of the interchange existing between the various areas.

Mineral resources of the mountain ridge area

As we have seen, the copper mining areas are concentrated in the Sumail Nappe, the ophiolitic belt running round both sides of the limestone platform of Jebel Akhdar (*Fig. 2*). The mineralizations present, both oxides and sulphates, are all extensively associated with iron ores. Native copper is very rare. The most common are oxidized deposits, e.g. brochantite, in the form of incrustations and coatings which were exploited both in ancient and in mediaeval times. Less common is chalcopyrite, which is occasionally found condensed in quartz veins. Iron ore is present in all stages of degradation down to haematites and limonites. There are many ancient mines and, thanks to the work done by Prospection Ltd. they have recently been pinpointed and studied (*Fig. 1*). However, it is hard to say to what extent the present availability of metal reflects the protohistorical situation at the dawn of metal prospection. As Charles points out (1975:23), native copper concentrations, or at least mineralizations with a high copper content, were much more frequent in the past than would be imagined today.

None of the ancient mines found so far can be linked to a possible protohistorical exploitation, except perhaps the one at Assayab near Wadi Jizzi (J. Humphries, personal communication). Fragments

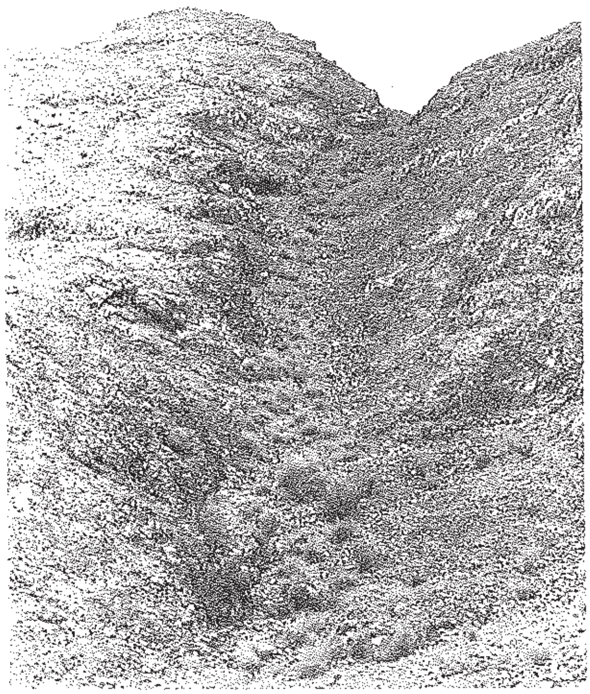

PLATE 12. *Lasail. Line of water flow with erosion of copper-bearing rock (gabbro). Azurite mineralizations are present in various places.*

PLATE 13. *Lasail. Detail of two crucible fragments lying among slag.*

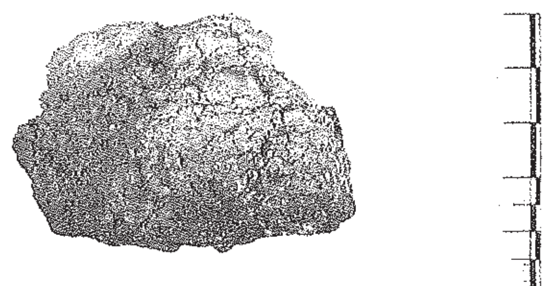

PLATE 14. *'Arja. Fragment of crucible with flint/jasper chips.*

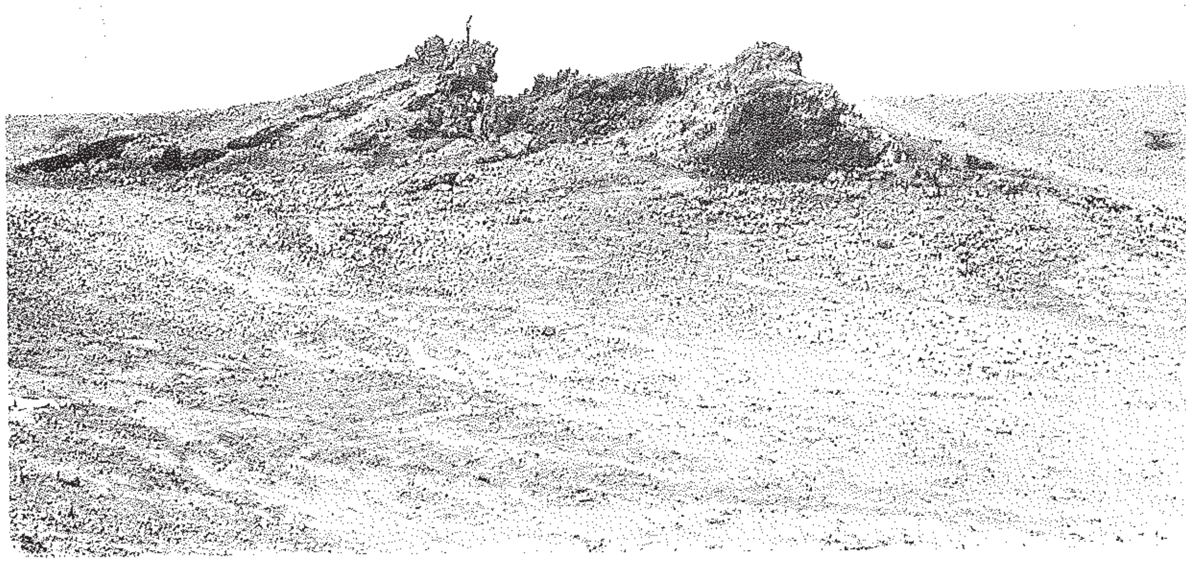

PLATE 15. *'Arja. View of ancient excavation work on a rock hummock along the copper-bearing vein.*

of crucibles and other casting waste have been collected by the Harvard Mission in various Wadi Andam sites, all of which can be assigned to the 3rd millennium B.C. There is no doubt that the copper was gathered and worked during the period of the Umm an-Nar Culture, although surface mining in the deposits or the gathering of metal-bearing pebbles from the *wadi* beds probably prevailed over actual mining operations. Especially in the Sharqiya where river erosion has cut deeply into the ophiolitic belt the latter method may well have provided considerable quantities of raw material.

All the mines we visited, Lasail and 'Arja on Wadi Jizzi, Masjad on the Luzaq, can be assigned at least to the middle ages (9-15th century A.D.) but the methods used for smelting the ore are very close to those known in south-east Iran during the 3rd millennium B.C. In any case, their study is still of prime importance in the history of Oman and that of metalworking in general.

Lasail (260 metres a.s.l. = m.: 24° 16′ N/56° 26′ E) in a side valley of Wadi Jizzi, the Tawi Ubaylah, on the lower slopes of the eastern side of a small gabbro formation. The mineral worked is brochantite which is contained in amygdaloid volcanic rocks in veins a few centimetres thick with 0.73-0.93 % copper (Corney, Welland: 33) (*Plate 11*). The melting zone covers an area of many hundreds of square metres, where p s with an average diameter of 1 m have been dug. There are also the remains of crucibles made of very ferrous clay to raise its melting point with heavy intrusions of crushed flint and gravel. These are conical in shape and have a raised base. The diameter at the rim was around 30 cm.

The site appears to be composed of a series of mounds of slag separated by flat areas covered with pulverized ferrous residue—haematites and limonites (*Plate 10*). According to the calculations made by Prospection Ltd. there is about 25,000 m^3 of slag at Lasail.

The smelting technique used seems to have been that of flotation whereby the copper boiling in the crucible separates from the matrix and floats towards the top, leaving behind a heavy ferrous deposit on the bottom (Anstel, 1966) (*Plate 13*). The smelting waste gathered was found to have a characteristic band composition with the copper increasing towards the top. The quantitative analysis of the slags carried out by Carney and Welland (1973: Table 3) shows an iron oxide (Fe_2O_2) content of 50.9%. X-ray fluorescence tests carried out by M. Salmi at the Nuclear Engineering Institute of the University of Rome have confirmed the constant presence of overall large percentages of iron.

'*Arja* (240 metres a.s.l. = 24° 21′ N, 56° 24′ E) lies a few kilometres from Lasail, again in the Wadi Jizzi area, at the junction of two fault-lines. The copper mineralizations, brochantite and chalcopyrite, are contained in basaltic rock. The copper smelting areas are found in a natural depression inside the circle of the hills and are laid out in a similar fashion to those of Lasail. Blocks of jasper are quite common. Excavation work has been aligned with the uppermost exposed seams (*Plate 14*).

The different processing areas are quite obvious. Three large slag heaps situated inside a deep extraction furrow seem to have covered the smelting areas which were gradually abandoned (*Plate 15*). The remains of dwellings with foundations consisting of large river stones appear on the outside of the working areas to the north alongside the small *wadi* of the same name. A few kilometres further north, at the site of Baida (24° 22′ N, 56° 26′ E) both copper and zinc have been found in amygdaloid rocks. There does not seem to be any significant chronological difference between the respective periods during which Lasail and 'Arja were exploited.

Masjad (23° 04′ 103 N/57° 55′ 303 E). This is the third site we visited. The site is on the Wadi Kurch about 10 km east of Wadi Sumail, the great communication artery between the coast and the Oman interior (*Fig. 1*). Here we are virtually already in the catchment basin of the Wadi Andam and thus the area can also be linked with the most important protohistorical settlement clusters discovered so far by the Harvard Mission (J. Humphries, personal communication).

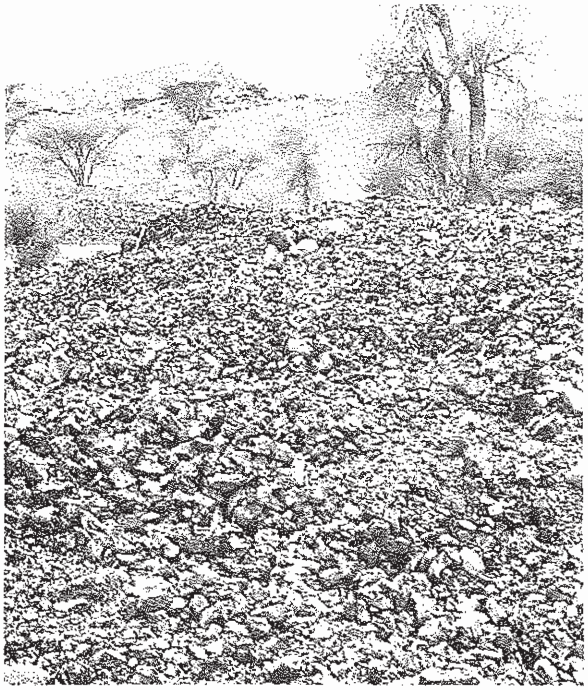

Plate 16. *'Arja. Overall view of slag heaps.*

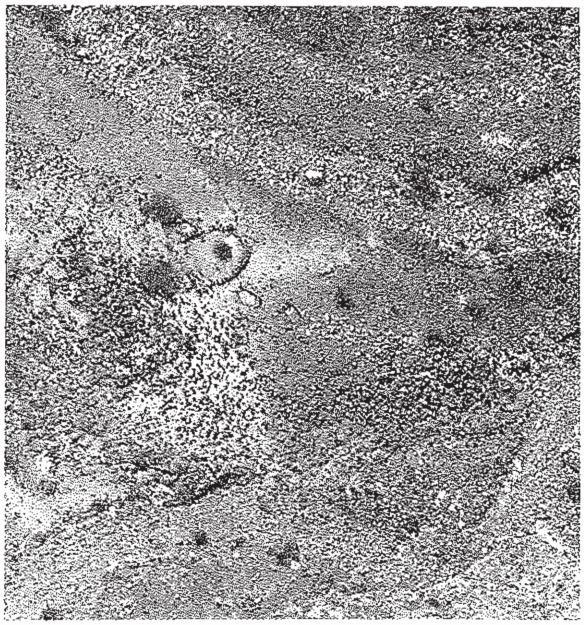

Plate 18. *Small smelting areas between two foothill* wadi *east of W. Sumail. The remains of a small building and two possible furnaces are visible surrounded by a mass of slag.*

Plate 17. *A small ancient mining area on the Wadi Sumail. The arrow indicates the crushing and smelting areas.*

The Masjad copper is contained in peridotite seams with sporadic occurrences of malachite in the layers worked.

The deposit consists of a series of seams crossing a dome-shaped hump (*Plate 19*). The mines are of both the pit and tunnel type. The former are shallow holes, 1 × 1 m, aligned in a row along the ore seam (*Plate 20*). This system of mining is typical of all the primitive mines of copper and its derivatives, particularly, turquoise. It is found more or less the same at Nishapur, in the Kyzyl Kumy (Vinogradov et al ii, 1965), at Wadi Magharah in Sinai (Petrie, 1906; Barron, 1930; Forbes, 1966: 126–130, fig. 8). In all these places turquoise mining is accompanied, more or less sporadically, by copper mining. The arrangement of the shafts along the outer surface of the metal-bearing seam is still today, except for Kozlu in central-north Anatolia, the system commonly used during the 3rd millennium for extracting all mineral resources (Forbes, 1965).

In another part of Masjad, perpendicular to the line of shafts there is a true tunnel, square in section and 37.5 m long with three air shafts, also square in section, at intervals of 9–10 m from each other. Two large heaps of chips of hammered ore are found respectively on the west side of the shafts and on the south side of the tunnel (*Plate 19*). Immediately after extraction the ore was prepared for smelting, which took place a few metres away where two slag heaps can be seen containing a total of 15,000 tons according to the calculations of Prospection Ltd. The remains of at least five houses can be seen between the two slag heaps. One of these has a more complex plan and is larger than the others (about 120 m^2). The whole complex could be dated as 14–15th century A.D. Neither the crucible fragments gathered nor the type of slag shows the slightest difference compared with the Lasail and 'Arja material.

In all the copper-producing areas we examined, the three main ore processing phases—extraction, crushing and smelting—were carried out in the same place and probably in a continuous cycle. The lack of water which prevails in all the mountainous areas of the interior, was no obstacle as the production cycle did not specifically require large quantities of it. Fuel was available in most places thanks to the *Acacia* thickets. This hard and slow-burning wood was the ideal fuel for flotation smelting which required an actual charcoal pit.

Carney and Welland pointed out, on the other hand, that sometimes the mining zone was situated some distance from the place where the product was worked, which was usually situated in valley hollows. According to them this was the case as regards two centres on the Wadi Sumail—one at Luzuq and the other SW of Nizwa. In both cases the product came from the mountain zone in the form of ingots, or at least semi-processed. Considering the three main areas in which the production sites were concentrated—Wadi Jizzi, Wadi Sumail, and the upper Sharqiya—the main beneficiaries of the copper production, and often the direct controllers of it, were obviously the settlements of the interior where the surplus of farm produce was much easier to preserve than food coming from the sea. The two zones were doubtlessly economically complementary to a certain extent. One possible exception is Sohar which was relatively close to the Tawi Ubaylah centres. Indeed the Wadi Jizzi represents a true artery of economic integration between the Indian Ocean coast and the foothill mining areas across the coastal mountain chain and the inland oasis of Buraimi which, if necessary, could also be extended across the 140 km of desert as far as Abu Dhabi. The cross-country axes Umm an-Nar—Sohar and Buraimi—Ibra are probably the main lines supplying the system of relations and interchange during the 3rd millennium B.C. so that the very complimentarity of the resources might have stimulated the process of cultural integration in the face of increasing population and a growing demand for goods.

The only direct elements available to us at the moment regarding the exploitation of metal resources during the 3rd millennium B.C. come from the discovery of crucible fragments in the protohistoric

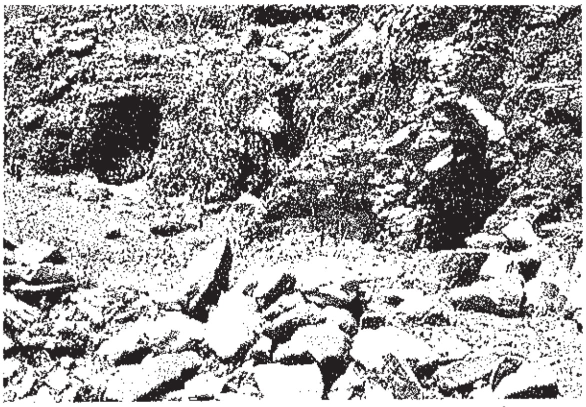

PLATE 19. *Masjad. Detail of mining pits in eastern creek.*

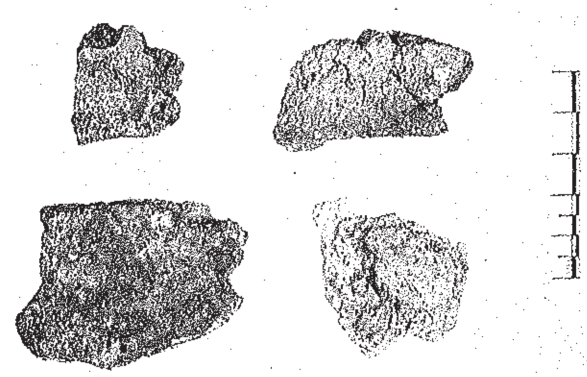

PLATE 21. *W. Ibra 2. Fragments of crucibles from bronze-age site.*

PLATE 20. *Masjad. Overall view of the site.*

PLATE 23. *Aerial view of a section of palm grove near the village of Nizwa.*

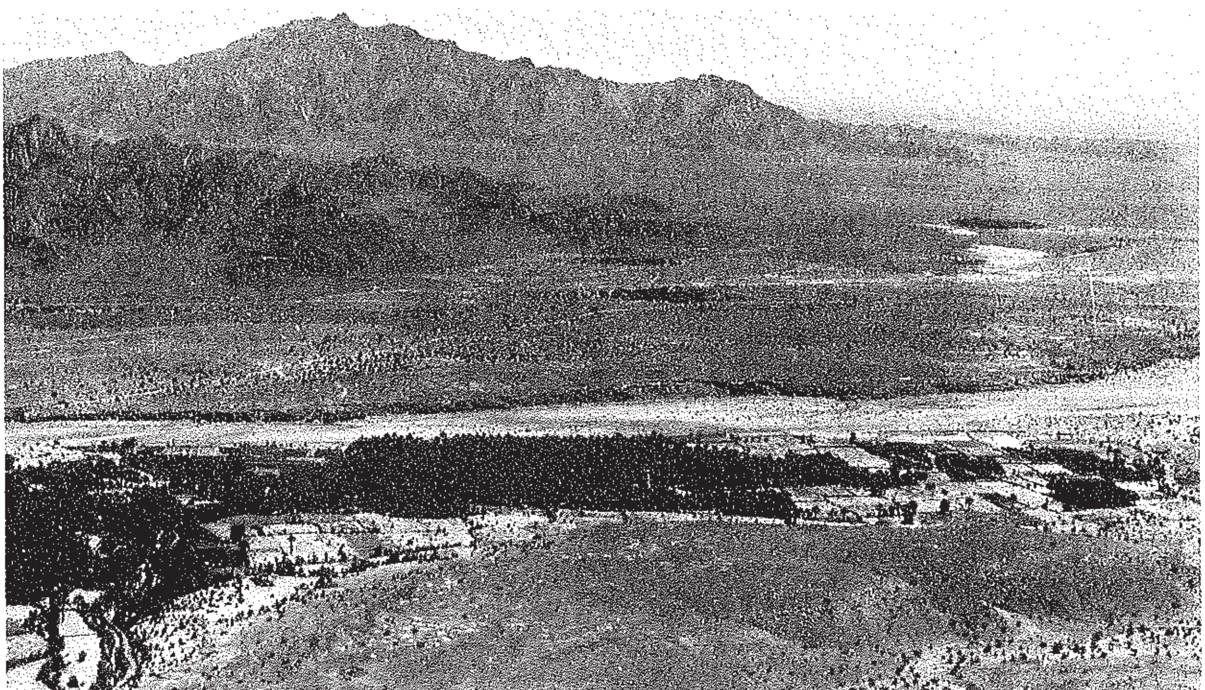

PLATE 22. *Islands in the desert. Typical layout of dwellings and fields in the inland foothill zone, both concentrated in the bed of the* wadi *on the terraces of which small farms can be seen that are probably supplied by vertical wells and very sparse halophyte vegetation.*

settlement of Wadi Ibra 2 made by the Harvard Mission. These are conical cup crucibles, 12-15 cm tall with a capacity of 500 cm^3. They are made of ferrous clay mixed with fine gravel and straw and have a wall thickness of 0.9–1.5 cm. (*Plate 21*). The shape and small size of the crucibles is very reminiscent of those found at Shafr-i Sokhta in Iranian Sistan dating to between 2600 and 2500 B.C. XRF analysis of the Shahr-i Sokhta crucibles has always indicated high percentages of residual iron and has given practically the same results as the specimens coming from Wadi Ibra 2.

The abundance of copper in Iranian Baluchistan (Bazin, Hübner, 1969: 153-7) rules out any possibility of there being any specific interchange between Oman and Sistan. However, the comparison is a useful one as it shows a general cultural convergence that is common to the whole of southeast Iran and Oman and leads to the technological level and production modes being the same. This may be considered as a significant factor in the 4th millennium relations between the two shores of the Gulf of Oman (Tosi, 1974).

Copper was not the only metal produced in ancient Oman. The region is known to abound in zinc and lead, as is only to be expected as a result of the same conditions of tectonic slipping as those that produced the copper-bearing ophiolitic belt (Forster, 1974: 14). A number of deposits have been discovered over the past few years in Wadi Hawasinah (Carney, Welland: 43, map 5) and in the metamorphic soils of Saih Hatat at the back of Muscat.

The latter report is rather significant as it can be linked to the discovery of some slag in Wadi Aday on a site in front of a series of rock drawings. XRF analysis has clearly shown them to be slag from lead-smelting containing varying amounts of iron and tin.

Lead is also present in significant quantities in the spectrographic-quantitative analysis of four bronze objects from graves I and II at Umm an-Nar (Frifelt, 1975). Lead is always present in the following percentage quantities:

	copper	lead	zinc	Pb Zn
lump	96	3.7	0.05	3.75
dagger	86	11.0	0.1	11.1
dagger	69	25.0	2.3	27.3
dagger	90	0.1	10.0	10.0

Lead and zinc are found to be in direct combination, which could mean that they were obtained from one and the same ore, e.g. the one found in area 184 of Wadi Hawasinah (Carney, Welland: 43). In view of the high to very high Pb/Zn content of the Umm an-Nar bronzes we are obviously dealing with alloys that were intentional and closely related to the type of resources available locally. This convergence is a factor confirming the T-scheme of routes we assumed to be the collecting canal in the interchange of resources.

Farming in the inland foothill strip

The third part of our survey of the exploitation and interchange of resources is without doubt more complex but at the same time based on scantier data. Thanks to the combined research of K. Frifelt, B. De Cardi and J. Humphries it can today be established that during the 3rd millennium B.C. human occupation was continuous over the whole piedmont strip from Buraimi to Ibra, i.e. over a total distance of 350 km, and concentrated in the *wadis* and the few oases with a spring. Settlements and graveyards have been found at Buraimi (Frifelt, 1975), Hafit (Frifelt, 1970) in Wadi al-Kabir, Wadi Amlah (De

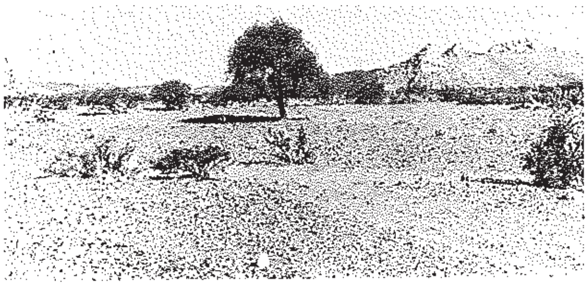

PLATE 24. *View of Wadi al-Ayn from the protohistoric settlement excavated by B. De Cardi. As in the case of present-day farm buildings it is situated directly on the river bed where the plant concentrations are highest.*

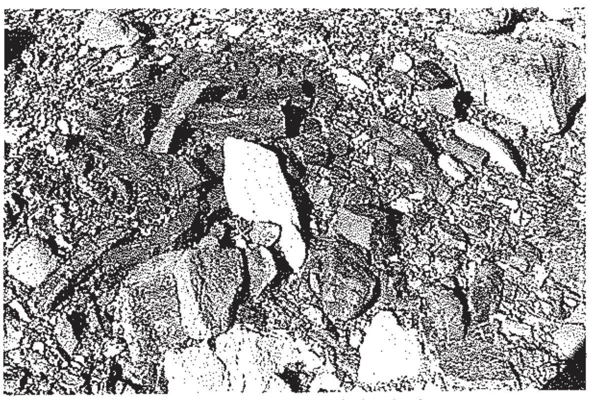

PLATE 25. *Wadi al-Ayn. Outcrops of bloodred jasper among the protohistoric dwellings.*

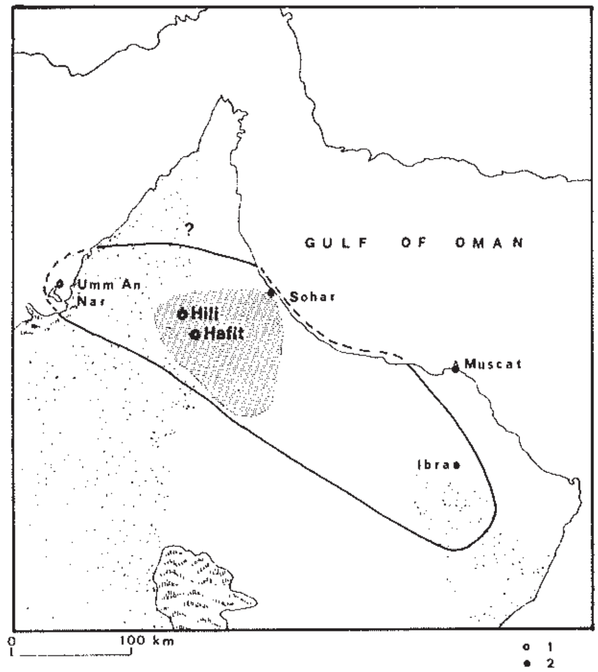

FIG. 5. *The minimum extension of territory controlled by the "Jemdet Nasr" horizon settlements (grey area) and the "Umm an-Nar" culture (encircled area) in Oman. 1: Ancient sites; 2: Modern settlements (drawing by I. Reindell).*

PLATE 26. *Bat. Protohistoric graveyard. Note the distribution of the cairns on the hill ridge.*

Cardi, personal communication), Wadi Bahla (Humphries, 1974: 50), Wadi Andam, Wadi Ithli, Wadi Ibra (Humphries, personal communication). The settlement model naturally follows a linear pattern aligning itself along the direction of river flow. The dwellings are mainly built on the bends, usually on the inside and too close to the bank to avoid being flooded on a number of occasions and often almost completely destroyed. This different arrangement of the settlements between the coast and the interior is the decisive factor in preservation; the closer we get to the sea the greater the degree of preservation, so that on the Batina coast we find actual *tells*. The situation is different in the case of the graves which are found on hilly ridges and, in any case, on high, non-irrigable ground. In the case of those of Wadi al-Kabir much use was made of two local resources—the white allotropic limestone of Jebel Kawr and the schist rocks of the Oman melange which split up into almost modular elements for the construction of the monumental tombs of Bat (*Plate 26*).

The decisive factor in siting the settlement was without doubt agricultural production, although some consideration must also have been given to resources essential for the manufacture of implements. Three materials were used for this purpose: jasper, chert and copper, The protohistoric settlement of Wadi Amlah, excavated by B. De Cardi, is built directly on top of an outcrop of high quality jasper. (*Plate 25*). The series of settlements in the *wadi* mentioned above is virtually self-sufficient in each of the basic resources: copper upstream, chert and/or jasper on the terraces or on the desert fringe further downstream. Chert is plentiful all over the allachthone Hawasinah strip in thin seams emerging from below the ophiolitic series of the *Sumail nappe* (Glennie et alii: geological map, sheet 2). Heavy concentrations occur round the series of Maastrichtian limestones towards Ras al-Hadd east of the area of the protohistoric farm settlements. Humphries has in any case discovered actual centres for the semi-processing of chert on the furthest reaches of Wadi Batha.

The farming settlements of the interior thus appear to be distributed as semi-independent units deliberately oriented towards beams of mountain or valley resources according to the axis of the watercourse on which they primarily depend for their food production (*Fig. 4*). The structures were clearly segregated and distributed over the higher terraces or in the non-cultivated *wadi* beds. The latter are always covered by a rather thick spontaneous vegetation consisting of *Acacia-Juniperus* associations, to which tree *Tamarix* must also be added in a number of areas in the Sharqiya. It thus does not deviate from the single-line logic of the agricultural settlement but is integrated with it and increases the range of available resources.

The fertility of the lower terraces on the river beds is undeniable, quite apart from the date palm which appears to have been grown in south-east Iran as is proved by figurative representations and ethnobotanical finds (Costantini, Tosi, 1974: fig. 18).Wheat and barley are sown in a continuous cycle with a high yield per hectare in the so-called '*awabi* land outside the palm grove (Burdon, 1973). A series of controlled fields in Wadi al-Kabir, which we observed at harvest time (March-April 1975) was found to have a dense population of *Triticum aestivum* (12 plants per 10 cm^2).

Even today the central part of inland Oman, where the larger settlements are situated 450-550 metres a.s.l., is the most densely populated part of the country, the only one in which the arable land accounts for 2% of the total. According to J. C. Wilkinson (1974) this percentage would be much lower than the figure he assumes for the 6th century B.C., i.e. when *qanat* were introduced for the first time from Achaemenid Iran. In fact, cereal and vegetable consumption might have represented a more complete utilization of available water as these plants have a wider range of adaptability and smaller water losses than the date palm which predominates today, a true cash crop owing to its protein sugar content and its long conservability.

The study of the protohistoric farm economy of inland Oman should thus be visualized and planned from a different standpoint, taking into consideration the following two factors which might have been characteristic of the ancient production system compared with the present-day one:
a) greater segregation of the single population groups which consequently required a greater and safer cultivated area with a prevalence of direct consumption species such as cereals and pulses.
b) the comparatively sporadic nature of the interchange, dependent as it is on limited and traditional demand levels.

The latter factor could well justify the considerable cultural continuity of protohistoric Oman, in a society concentrated in villages scattered over the territory. Tribal survival, an opposing factor and dialectical antagonist of the formation of the state, is apparent in the determining locational concentricity found in every Umm an-Nar settlement in inland Oman: graves—village—wadi. The living community is thus hemmed in, and not only symbolically, between the means of survival and the weight of tradition. It is only logical, therefore, that there should be this surprising similarity between the circular shape of the houses and that of the graves (Wadi Amlah, BB-19 and BB-21 in Wadi Bahla). Too often the settlements consist of a single round tower-house, divided up into several rooms, which are arranged concentrically around the fire-place (Hili) or a courtyard (?) as in BB-21 (Humphries, 1974: fig. 4, Frifelt, 1975: fig. 4). A series of square buildings often surround the round "towers" (BB-18); this could point to a social structure that was not entirely centred round the clan.

Conclusions

The picture we have given here provides only a disconnected and imperfect idea of the situation. Diachronic-historical perspective has been deliberately flattened out into a synchronic phenomenology to indicate more clearly the dependence of socio-political structuring in the environmental conditions of the territory. The limited data available restricts us to making vague generalizations and the synchronic perspective allows us at the beginning to concentrate the few available elements, no longer according to the logic of evolution and cultural change, but according to environmental and economic determinism. Oman is a rich land but the distribution of its resources is quite peculiar and not at all homogeneous. This has led to the introduction of mechanisms aimed at guaranteeing survival by means of population concentration in the available areas and interchange with other regions possessing complementary resources. One of the consequences of this was, during the 3rd millennium B.C., the widespread occupation of the territory: the settlements of the second half of the millennium (Umm an-Nar) are scattered over an area that is at least three times larger than that occupied by the settlements of the first half (Jemdet Nasr horizon of Hafit and culture of Wadi Suq). The territory between Umm an-Nar and Wadi Ibra covers about 45,000 km² while the area occupied by the older settlements is concentrated in Wadi Jizzi on both sides of the Oman mountains with a total area of about 14,000 km² (*Fig. 5*).

In spite of the unquestionable progress made in controlling the territory and its resources, in spite of the opening up of cultural and economic interchange with south-east Iran (Tosi, 1974) and with the island of Bahrain (Bibby, 1975), the protohistoric culture of Oman does not provide the necessary conditions for urban or state development. The general evidence accummulated up to date seems to indicate that the very same mechanisms which allowed such a difficult, environmentally specialized territory to be colonized later hindered the socio-economic integration of the resources. It is probably the beginning of this same state of conflict between family groups that has often afflicted Oman and slowed down its civilized development.

ANSTEE J. W. (1966), Copper Smelting Experiments, *Bulletin of the Historical Metallurgical Society*, 7, pp. 3–12.

BAZIN D., HÜBNER H. (1969), *Copper Deposits in Iran* (*Geological Survey of Iran*, Report 13), Tehran.

BIBBY G. (1975), The Umm an-Nar Culture in Bahrain, *Paper read at the III International Conference of the Association for South Asian Archaeology*, Paris, July 1–3.

BERDON D. J. (1973), Current Problems and Prospect for Agricultural Development in the Sultanate of Oman. (*Report of a joint* FAO/UNDP *Preparatory Assistance Mission, vol. VI: Water Resources*), Rome.

BURRON T. (1938). *The Topography and Geology of the Peninsula of Sinai* (*Western Portion*), London.

CARNEY J. N., WELLAND M. J. (1973), *Geology and Minerary Resources of the Oman Mountains*, London.

CHARLES J. A (1975), Where is the Tin?, *Antiquity*, XLIX, pp. 19–24.

CONSTANTINI, L., TOSI, M. (1974), *Methodological Proposals for Palaeobiological Research in Iran*, *Proceedings of the IIIrd Annual Symposium on Archaeological Research in Iran*, Tehran, 1975, pp. 311–330.

FORBES R. J. (1965), *Studies in Ancient Technology, vol. VII: Ancient Geology and Mining*, Leiden.

FORBES R. J. (1972), *Studies in Ancient Technology, vol. IX: Metallurgy in Antiquity, part II*, Leiden.

FRIFELT K. (1970), *Jamdat Nasr Fund fra Oman*, *KUML*, pp. 355–383.

FRIFELT K. (1975a), Archaeologische Forschungen am Perischen Golf, *Antike Welt*, VI, pp. 15–24.

FRIFELT K. (1975b), On Prehistoric Settlement and Chronology of the Oman Peninsula, *East and West*, XXV, forthcoming.

GLENNIS K. W. et alii (1974), *Geology of the Oman Mountains* (*Verhandelingen van het koninglijk Nederlands geologisch mijbouwkindig Genootschap*, XXXI).

HARRISON D. L. (1968), *The Mammals of Arabia*, vol. II, London.

HUMPHRIES J. (1974), Harvard Archaeological Survey in Oman: II–Some Later Prehistoric Sites in the Sultanate of Oman, *Proceedings of the Seminar for Arabian Studies*, IV, pp. 49–77.

LAMBERG-KARLOVSKY C. C., TOSI M. (1973), Shahr-i Sokhta and Tepe Yahya: Tracks to the Earliest History of the Iranian Plateau, *East and West*, XXIII, pp. 21–57.

PETRIE W. M. F. (1906), *Researches in Sinai*, London.

THORVILDSEN K. (1962), *Burial Cairns on Umm-an-Nar*, *KUML*, pp. 197–219.

TOSI M. (1974). Some Data for the Study of Prehistoric Cultural Areas on the Persian Gulf, *Proceedings of the Seminar for Arabian Studies*, IV, pp. 145–171.

VINOGRADOV A. V., LOPATIN S. V., MAMEDOV E. D. (1965), Kyzylkumskaja birjuza, *Sovetskaja Etnografija*, pp. 114–134.

WILKINSON J. C. (1974), The Organisation of the Falaj Irrigation System in Oman, *Research Paper no.* 10, *School of Geography*, Oxford.